PROTOTYPE DEVELOPMENT OF NORMAL ASIAN HUMAN SKULL

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ABSTRACT

Skull which is cover with scalp is skeletal structure of human’s head that protect and form a cavity for the brain, where the nervous system is. Nowadays, prototype of human’s skull model needed in wide use such as to educate and train physicians, inform patient, support R&D and for surgical planning The purpose of this study is to build a three dimensional of normal Asian human’s skull by using any applicable machine. The process of replicating human’s skull start with two dimensional Computed Tomography(CT) data that need to be translate into three dimensional rapid prototyping data by using MIMICS software. The three dimensional(3D) skull model need to be observed and measure as the scope of this project focused to specific normal Asian human. The observation of its morphological features of the skull and linear measurement had found that the 3D skull model belong to normal Asian human. Then, the 3D file images will be exported into related software for fabrication of prototype process. The prototype development had be done by using modeler machine that use subtractive concept The skull prototype that made up from chemical wood, or its specific name, miraboard 700 undergoes drop ball experiment for capability determination of the skull prototype. For validation, the drop ball test experiment result was compare to result of analytical method. The research comes out with almost the same value percentage different between the experimental and analytical method.

ABSTRAK

Tengkorak yang diliputi kulit kepala adalah merupakan rangka kepala manusia yang berfungsi untuk melindungi dan menghasilkan kaviti untuk otak dimana terdapatnya sistem saraf. Kini, prototaip tengkorak adalah diperlukan secara meluas bagi tujuan pendidikan, latihan ahli fizik, pemberitahuan kepada pesakit, menyokong kajian dan pembangunan dan rancangan untuk pembedahan.Tujuan kajian ini adalah untuk membina sebuah prototaip tengkorak untuk orang Asia yang normal. Proses membina prototaip ini bermula dengan imej dua dimensi daripada imbasan komputasi tomografi.yang akan ditukar kepada imej tiga dimensi menggunakan program khusus yang dikenali sebagai MIMICS. Imej tengkorak tersebut mesti menjalani proses pemerhatian dan pengukuran bagi memastikan ianya mencapai objektif projek, iaitu menghasilkan tengkorak untuk orang Asia normal.Seterusnya, imej tersebut akan dieksport didalam format STL kepada program yang berkaitan untuk proses pembinaan. Proses pembinaan tengkorak ini telah disiapkan menggunakan mesin modeler, yang menggunakan proses penolakan. Prototaip tengkorak ini yang diperbuat dripada kayu kimia, atau nama spesifiknya adalah miraboard 700 akan menjalani eksperimen impak kepala bagi mengenalpasti kemampuannya berbanding prototaip tengkorak yang lain. Untuk proses pengesahan, keputusan eksperimen telah dibandingkan dengan keputusan yang menggunakan kaedah analisis. Kajian ini telah mendapati peratusan perbezaan yang hampir sama berbanding keputusan eksperimen dan kaedah analisis.

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LIST OF SYMBOLS

g	Gravitational acceleration
s	seconds
E	Young Modulus
v	Poisson ratio
h	Thickness
R	radius
m	mass

LIST OF ABBREVIATIONS

CAD	Computer Aided Design
RP	Rapid Prototyping
2D	Two dimensional
3D	Three dimensional
FEA	Finite Element Analysis
CT	Computed Tomography
MRI	Magnetic Resonance Image
SLA	Stereolitograph
SLS	Selective laser sintering
MIMICS	Materialise's Interactive Medical Image Control System
DICOM	Digital Imaging and Communication in Medicine
DAQ	Data Acquisition
FYP1	Final Year Project 1
FYP 2	Final Year Project 2

CHAPTER 1

INTRODUCTION

1.1 PROJECT BACKGROUND

Human head is a very complex structure consisting of numerous objects with various mechanical properties. Three main components of human's head are skull, scalp and brain which have their own role for human's system. Skull which is cover with scalp is skeletal structure of human's head that protect and form a cavity for the brain, where the nervous system is. Nowadays, prototype of human's skull model needed in wide use such as to educate and train physicians, inform patient, support R&D and for surgical planning.

Leonardo da Vinci was the first to model brain structure by injecting molten wax into the ventricle of an oxen brain. Since then, neuron anatomical models have shown utility in neuroscience and medicine in areas such as education, diagnosis, and surgical planning. Currently, classical modeling techniques are being supplanted by modern methods that emphasize three-dimensional anatomical relationships using imaging techniques (Daniel J.Kelley et al., 2007).

The introduction of rapid prototyping technology has allowed three-dimensional models of human's structure such as skull, brain and bones to be available. Rapid prototyping technology was widely used for prototype development of human's structure with accurate features and sizes. One of the best rapid prototyping techniques is stereolitography. Its medical application was first introduced in 1991 at the Clinic for

Maxillofacial Surgery in Vienna (Lindner et al., 1995). The current clinical applications of the SL model are vast and expanding rapidly.

In modern technology, three dimensional reconstructed image derived from computed tomography (CT) data was the best option available for evaluation and treatment of surgical problems in dental surgery and various other specialties. (A.Nizam et al., 2006) Its main uses are for diagnostics and treatment planning in the field of dental surgery, oncologic surgery, reconstructive surgery and craniofacial surgery (Kermer, 1999). Other uses of such models are as in advance dental implantology procedures, documentation of unusual cases, training of junior staffs and students and patients' education via excellent communication between surgeons and patients in the presence of the model (Ramieri *et al*., 1999).

1.2 PROBLEM STATEMENT

Technology in rapid prototyping was widely used for many bioscience used. Many natural objects such as skeletal parts, fossil bones or cellular structures can be replicate by using rapid prototyping. However, working with rapid prototyping (RP) technologies in the biosciences differs radically from using them in computational aided design(CAD) environments. In CAD, model is planned and conceived entirely on the computer screen, then converted to physical reality. In bioscience applications, the objects already exist physically. Building models of them essentially involves reverse engineering, starting with acquiring data such as a stack of cross-sectional CT images. Prior to building a replica, these highly complex data need extensive preprocessing (Zollikofer C.P.E et al, 1995).

In the field of human and sport engineering, the rapid skull prototype model is used for education and for experimental study. For example, researcher will use skull prototype model for head impact experiment. In order to get most accurate result of the experiment, the skull model must have almost same dimension and properties to the real human skull. This problem can be overcome by rapid prototyping technology. It will produce skull prototype model from reformatted CT or MRI image which directs the ultraviolet laser beam to draw layer by layer of the desired structure of skull. In this present study, prototype of human skull is focusing on Asian race.

1.3 OBJECTIVES OF STUDY

The objectives of this study are:

(i) To develop three dimensional prototype of normal Asian human skull.
(ii) To determine the capability of prototype of normal Asian human skull through drop ball test experiment

1.4 SCOPES OF STUDY

The following scopes of the study are determined in order to achieve the objectives of the project:

(i) The human's skull model must follow the morphology features of Asian skull.
(ii) The human's skull model must have standard dimension of normal human.
(iii) Prototype of skull model will undergoes drop ball test experiment on force plate in order to check its capability.
(iv) Two different material skull prototype will undergoes drop ball test which are chemical wood skull, the present study and the Acrylonitrile butadiene styrene(ABS) skull, from the previous study
(v) The experiment between the two different materials skull prototype need to be done in order to determine the capability of the present study skull prototype.
(vi) In order to validate the drop ball test experiment results, this study will used analytical method.

1.5 REPORT ARRANGEMENT

This report is divided into five chapters. The chapter one is the introduction about the project. It is includes the brief project, problem statement, project objectives and the scopes of the study.

The chapter two is discussed about literature review. This chapter provided with introduction of the project design strategies and methods. In here, the general methods to build three dimensional human skull models have been discussed. Then it also includes the brief introduction to various methods to determine the accuracy of the skull model, the way to reconstruct skull model by using rapid prototyping and comparison with previous research method.

The chapter three is discussed about methodology of the project. Firstly the design of project study and frame work is studied. Then it moves to the steps before the STL data of skull will undergoes three dimensional printing processes. . In this study, the design of the project will separate into two work flow, which by the end of this project, the results from the two work flow will be comparing.

The chapter four is focusing on preliminary results and discussion. The three dimensional skull drawing is printed. Then followed by drop ball test for capability determination. Both of the existing result will be comparing. The results also have been analyzed.

The chapter five is about the conclusion and recommendations are made based on the results that have gain in the research. This chapter also mentioned about the alternative way to improve the way of creating rapid prototyping human's skull.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, it basically describes more about the studies on rapid prototyping process of human structures like skull, brain and teeth with different purpose. Human's skull rapid prototyping processes which has been done earlier by other researchers. It also discussed about the method used to check accuracy of the three dimensional rapid prototyping skull models with the real model by using different ways.

2.2 ANATOMY AND MATERIAL PROPERTIES OF HUMAN HEAD

Human head is a very complex structure with numerous objects that having many mechanical properties (S. G. M. Hossain, 2010). The head consists of a facial area and cranial skull surrounded by the scalp. The main components of head are skull, brain, scalp and cerebrospinal fluid (S. G. M. Hossain, 2010)

2.2.1 The Skull

The skeletal structure of the head is divided into three major parts: neurocranium (housing of the brain), face and base. Neurocranium is made of eight bones: frontal, two parietal, two occipital, sphenoid and ethmoid (N. Yoganandan, 2001). The following figures illustrate these bones making up the human skull (A.Halim,2009)

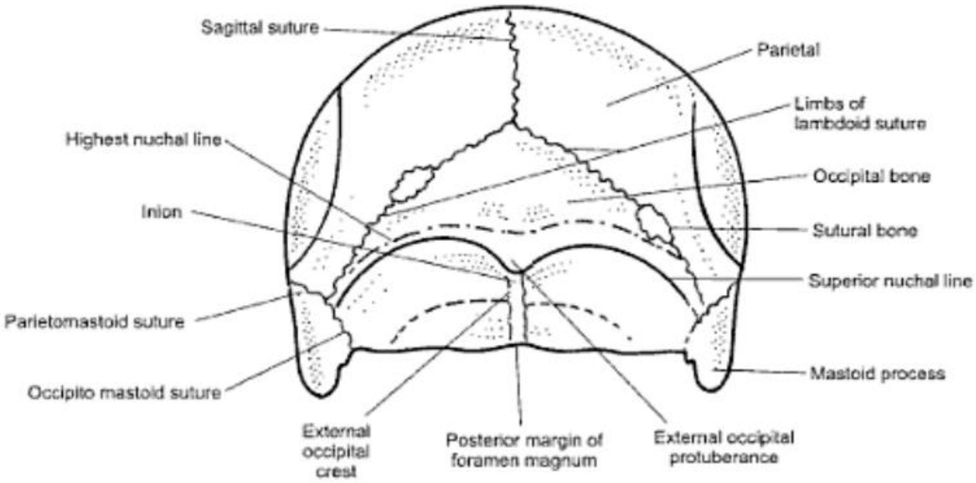

Figure 2.1: Posterior view of the skull

Source: A.Halim (2009)

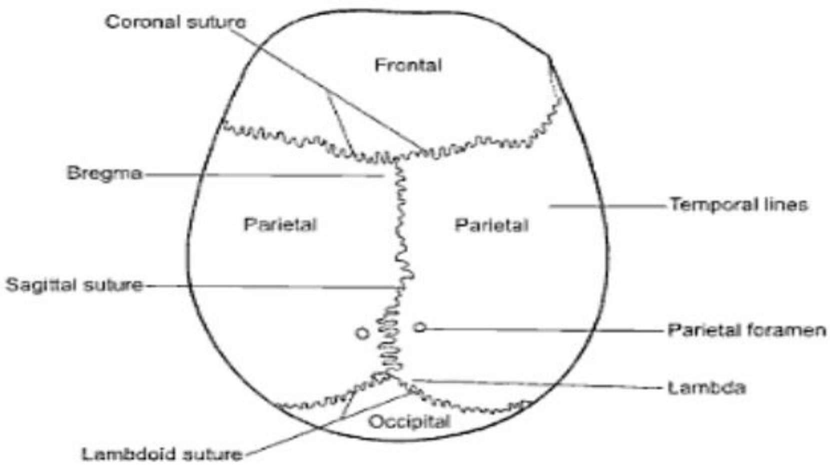

Figure 2.2: View of skull from above

Source: A.Halim(2009)

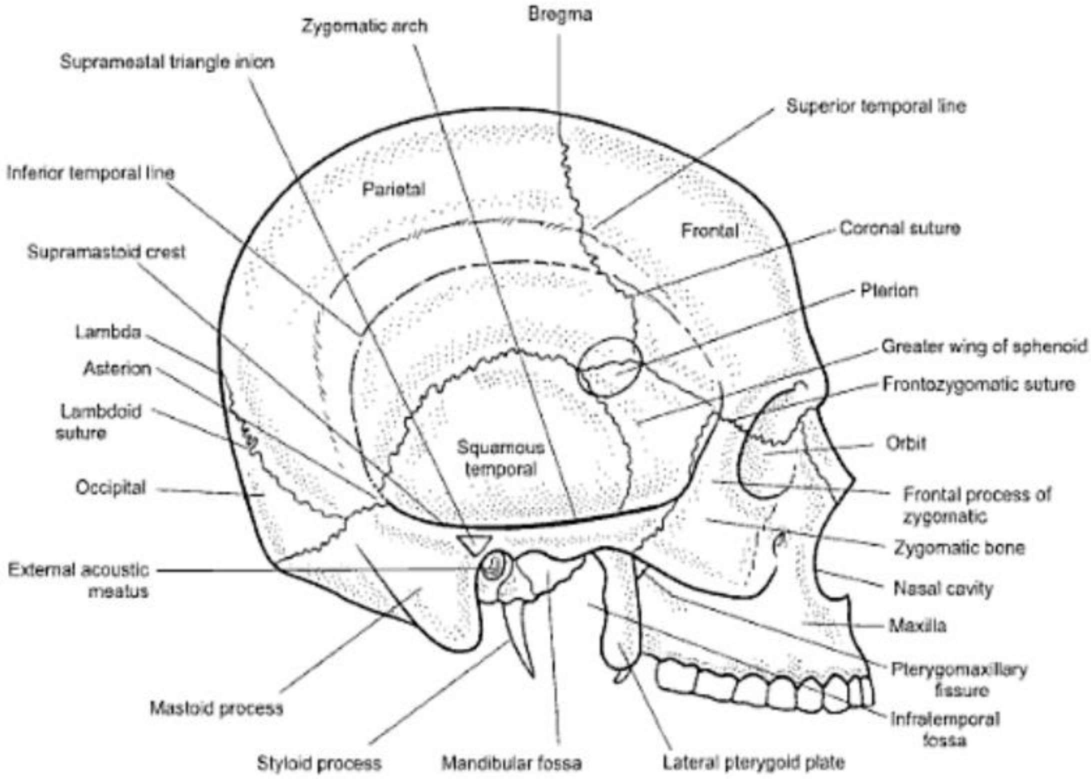

Figure 2.3: View of skull from lateral position

Source: A.Halim (2009)

2.2.2 The Brain

Human brain is made of mainly two types of cells: neurons and glia. Neurons are the cells that enable the nervous system to carry out all the complex computational functions. A typical human brain weighing 1.3 kg and with a size of 1.5 liters contains an estimated number of 20-100 billion neuron cells. The glial cells are described as the supporting cells for the nervous system; those play an important role of allowing the nervous system to work properly. The estimated number of glial cells in an average human nervous system is 10 times the number of neuron cells (S. G. M. Hossain, 2010)

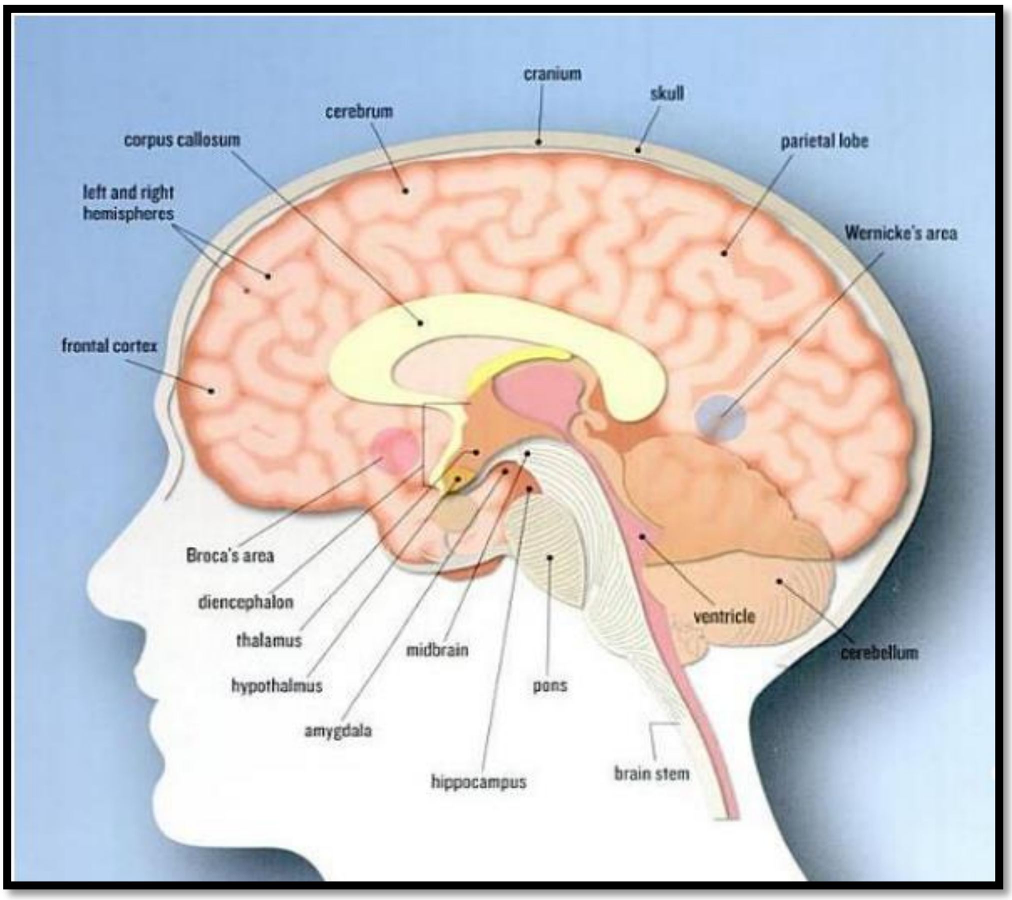

Figure 2.4: Various part of human brain

Source: S. G. M. Hossain (2010)

2.3 ASSESSMENT OF RACE FROM SKULL

Race concept in the first half of 20th century: so compartmentalized as "species" in the taxonomic sense. (Weidenreich,1947). The dilution during the past century is explicit in the statement "For those of us who were adults in 1950, the old criteria (on race identification) probably still apply. For those born between 1940 and 1970, modifications are probably needed. For those of us born since 1970, the nature and degree of change is mostly unknown, but the probability of change is almost certain" (Hoyme and Iscan ,1989)

2.3.1 Determination of Asian Race skull

Over the years, race determination has relied primarily on the morphologic features of the skull and facial skeleton since these provide consistently reliable results in the majority of cases. The three traditional classifications used for race determination are:-

a) Caucasoid (White-Europeans, Mediterranean and Americans)

In Whites, this complex includes a high, wide, skull, low cheek, short, gracile zygomatic arches, orthogenetic face, narrow interorbital distance, pointing chin, high nasal bridge, sharp nasal sills, and narrow nasal aperture.

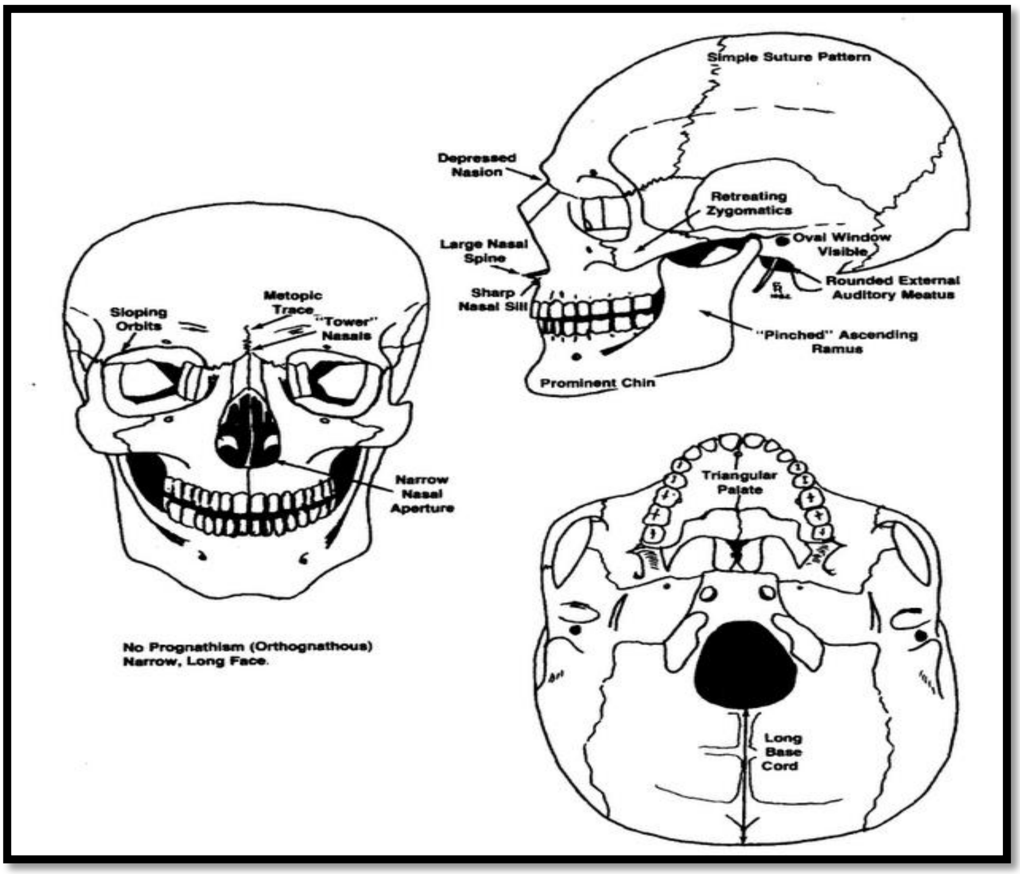

Figure 2.5: Morphological feature of Caucasoid

Source : http://yokeyan-mymind.blogspot.com/2010/12/ill-strain-my-nerves-to-help-

(b) Mongoloid (East Asian-Asiatic and native Americans)

The Mongoloid complex features a rounder skull, anterior and laterally projecting zygomatic bones, flat face with little projection, shallow nasal root, and shovel-shaped incisors. The most distinctive Mongoloid feature is the cheekbones. They exhibit high malar projection, both anteriorly and laterally, as well as a malar tubercle at the inferior aspect of the zygomaxillary suture. Also, shovel-shaped incisors are much more frequent in Mongoloids.

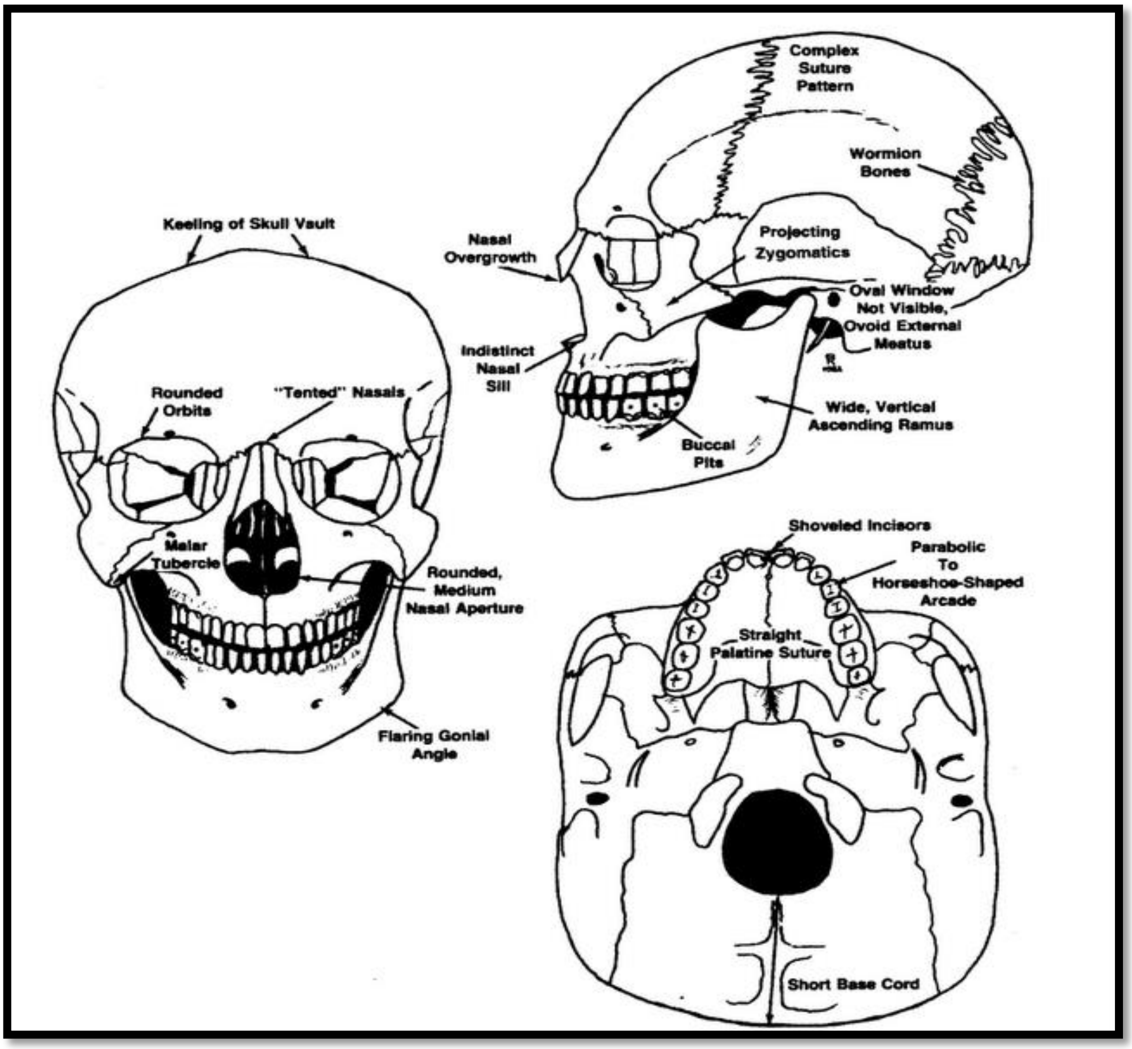

Figure 2.6: Morphological feature of Mongoloid

Source: http://yokeyan-mymind.blogspot.com/2010/12/ill-strain-my-nerves-to-help-

b) Negroid (Black-Africans and African Americans)

The Black complex is characterized by a long, low, narrow skull, long and robust zygomatic arches that project laterally (relative to the narrowness of the head), alveolar prognathism, wide interorbital distance, receding chin, low nasal bridge, smooth and guttered nasal sills, and wide nasal aperture.

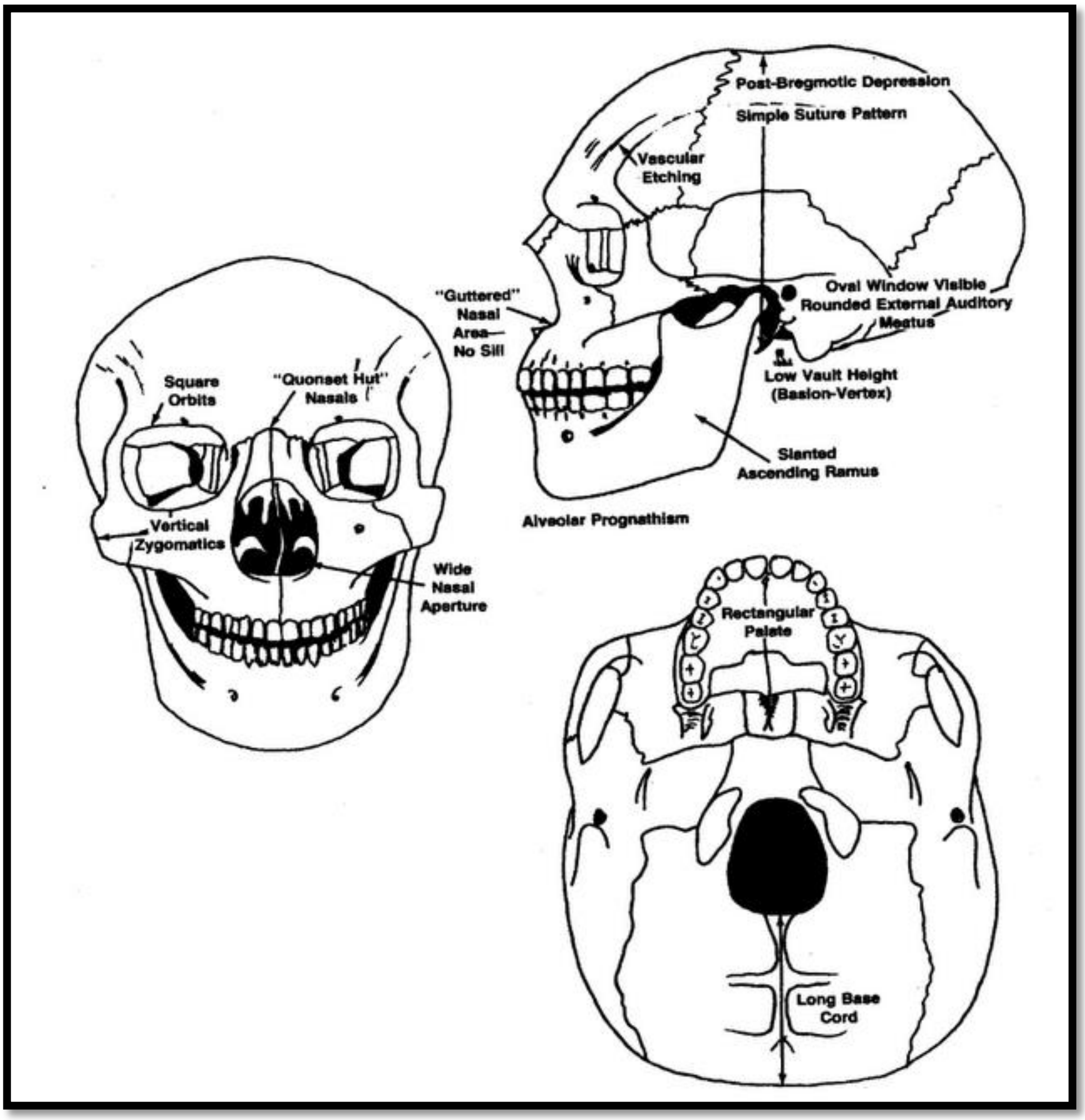

Figure 2.7: Morphological feature of Negroid

Source: http://yokeyan-mymind.blogspot.com/2010/12/ill-strain-my-nerves-to-help-

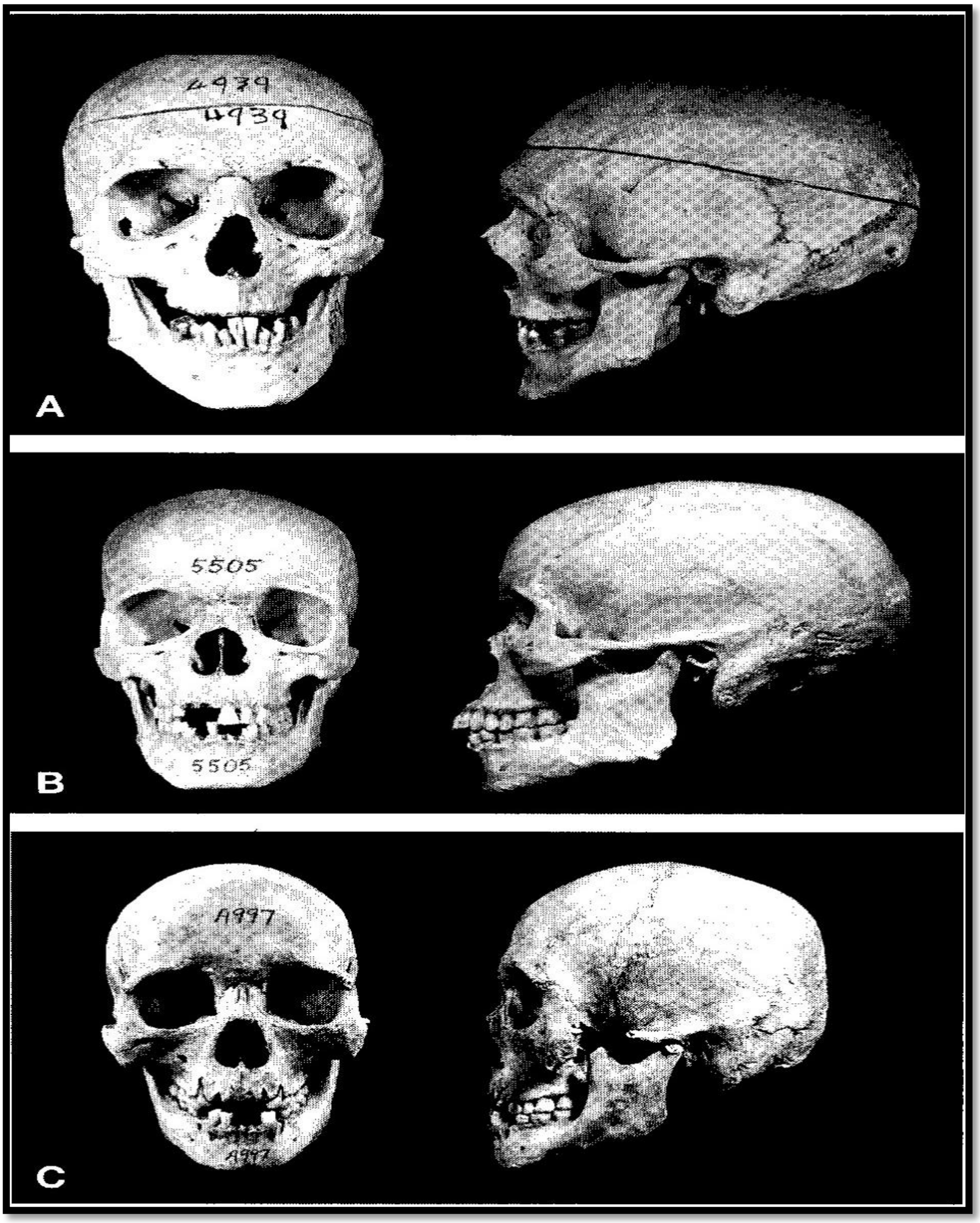

Figure 2.8: Different characteristic for different race (a) Caucasoid-Whites tend to have a high, wide head (b) Negroid- blacks often exhibit long, low crania. (c) Mongoloid- Mongoloids are more rounded with flat face

Source: P.T. Jayaprakash (2011)